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Mechanical thrombectomy with combined stent retriever and contact aspiration versus stent retriever alone for acute large vessel occlusion: data from ANGEL-ACT registry

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ABSTRACT

Background and purpose An analysis of the ASTER 2 trial revealed similar final recanalisation levels and clinical outcomes in acute large vessel occlusion (LVO) stroke between stent retrieval (SR) alone as a first-line mechanical thrombectomy (MT) technique (SR alone first-line) and concomitant use of contact aspiration (CA) plus SR as a first-line MT technique (SR+CA first-line). The purpose of the present study was to compare the safety and efficacy of SR+CA first-line with those of SR alone first-line for patients with LVO in China.

Methods We conducted the present study by using the data from the ANGEL-ACT registry. We divided the selected patients into SR+CA first-line and SR alone first-line groups. We performed logistic regression and generalised linear models with adjustments to compare the angiographic and clinical outcomes, including successful/complete recanalisation after the first technique alone and all procedures, first-pass successful/complete recanalisation, number of passes, 90-day modified Rankin Scale, procedure duration, rescue treatment and intracranial haemorrhage within 24 hours.

Results Of the 1233 enrolled patients, 1069 (86.7%) received SR alone first-line, and 164 (13.3%) received SR+CA first-line. SR+CA first-line was associated with more thrombectomy passes (3 (2–4) vs 2 (1–2); β=1.77, 95% CI=1.55 to 1.99, p<0.001), and longer procedure duration (86 (60–129) min vs 80 (50–122) min; β=10.76, 95% CI=1.08 to 20.43, p=0.029) than SR alone first-line group. Other outcomes were comparable (all p>0.05) between the two groups.

Conclusions Patients undergoing SR+CA first-line had more thrombectomy passes and longer procedure duration than patients undergoing SR alone first-line. Additionally, we suggested that SR+CA first-line was not superior to SR alone first-line in final recanalisation level, first-pass recanalisation level and 90-day clinical outcomes in the Chinese population.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The ASTER 2 trial failed to demonstrate that stent retrieval (SR)+contact aspiration (CA) first-line was superior to SR alone first-line in final angiographic and clinical outcomes. However, in the Asian population, there are few comparative analyses between SR+CA first-line and SR alone first-line for large vessel occlusion (LVO).

WHAT THIS STUDY ADDS

⇒ Our study, including the patients from a prospective, multicentre registry study, found that the combination of SR and CA first-line was associated with more mechanical thrombectomy (MT) passes and longer procedure duration than SR alone first-line. However, SR+CA first-line may be more effective than SR alone first-line in certain patients with LVO, such as patients undergoing general anaesthesia or without atrial fibrillation. Furthermore, we confirmed the results of the ASTER 2 trial in that SR+CA first-line was not superior to SR alone in final recanalisation level, first-pass recanalisation level and 90-day clinical outcomes in the Chinese population.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

⇒ Our results should be highly considered during the MT. Nevertheless, a large randomised controlled trial which is conducted in Asian countries is warranted.

INTRODUCTION

The safety and efficacy of mechanical thrombectomy (MT) by stent retriever (SR) for acute anterior circulation proximal large vessel occlusion (LVO) have been proven by five randomised controlled trials (RCTs).[1] However, there are two main MT techniques: SR thrombectomy and contact aspiration (CA) thrombectomy by aspiration catheter (AC).[2] Two RCTs have demonstrated similar angiographic and clinical outcomes between SR and CA thrombectomy.[3 4] As known to us, reperfusion is a strong predictor of good clinical outcomes in patients with LVO.[5] Consequently, how to improve the reperfusion level

with the best technique is still a hot topic in the era of MT. Several observational studies reported the concomitant use of CA during SR (SR+CA) as a more efficient technique.[6–11] However, the recent RCT—ASTER 2 (Combined Use of Contact Aspiration and the Stent Retriever Technique vs Stent Retriever Alone for Recanalization in Acute Cerebral Infarction)—demonstrated that SR+CA as first-line MT technique (SR+CA first-line) resulted in similar final angiographic and clinical outcomes with SR alone as first-line MT technique (SR alone first-line); the trial may have been underpowered to detect more minor differences between groups.[12]

Currently, in the Asian population, there are still few comparative analyses between SR+CA first-line and SR alone first-line for patients with LVO. As a result, we sought to investigate the safety and efficacy of SR+CA first-line compared with SR alone first-line for LVO in the Chinese population.

METHODS

Study population

From November 2017 to March 2019, the Endovascular Treatment Key Technique and Emergency Work Flow Improvement of Acute Ischemic Stroke (ANGEL-ACT) registry was a large prospective registry study and was carried out in 111 hospitals across 26 Chinese provinces, enrolling 1793 consecutive patients with LVO receiving endovascular thrombectomy (EVT). The previous study reported the complete registry methods of the ANGEL-ACT registry, including the data collection methods, inclusion/exclusion criteria, and imaging interpretation methods.[13]

We used data from the ANGEL-ACT registry in our analysis. Patients were excluded according to the following reasons: no EVT records, anterior cerebral artery (ACA) or posterior cerebral artery (PCA) occlusions, missing value for 90-day modified Rankin Scale (mRS), and CA first-line or intra-arterial thrombolysis (IAT) first-line or balloon angioplasty first-line or stenting first-line.

Data collection

All variables in our study were prospectively collected. The investigators who received training and got the qualification certificates recorded the National Institutes of Health Stroke Scale (NIHSS) and mRS scores.

The imaging interpretation was conducted by the imaging core laboratory, which was blinded to all clinical information. They assessed the images that included baseline brain CT, brain CT angiography, brain MRI, brain magnetic resonance angiography, digital subtraction angiography and brain CT after EVT. Alberta Stroke Program Early CT Score (ASPECTS) for the anterior LVO and posterior circulation ASPECTS for the posterior circulation LVO, tandem occlusion, underlying intracranial atherosclerosis disease (ICAD) (defined as more than 70% of fixed stenosis or more than 50% of fixed stenosis accompanied by distal blood flow impairment or the repeated reocclusive evidence after MT),[14] procedural complications including intraprocedural embolisation, vasospasm requiring treatment, artery perforation and artery dissection and modified Thrombolysis in Cerebral Infarction (mTICI)[15] were included in the imaging interpretation. We used site-reported data when patients' images could not be obtained. The imaging review criteria were the same between local investigators and the core laboratory, except that previous images indicated fixed stenosis at the occlusion site, which could also determine underlying ICAD.

Thrombectomy procedures

SR alone thrombectomy technique

The guide catheter was advanced over a 5 French/125 cm catheter and a 0.035-inch guidewire into the internal carotid arterial segment of interest or dominant vertebral arterial segment of interest. The microcatheter (0.021–0.027-inch inner lumen) was navigated through the thrombus to the distal end of the target artery by a microwire (0.014-inch diameter). Then, the SR was advanced through the microcatheter and deployed across the thrombus. Finally, about 5 min after deploying SR, the SR was withdrawn.

SR+CA thrombectomy technique

The guide catheter was advanced over a 5 French/125 cm catheter and a 0.035-inch guidewire into the internal carotid arterial segment of interest or dominant vertebral arterial segment of interest. A microcatheter (0.021–0.027-inch inner lumen) with a microwire (0.014-inch diameter) was used to guide the AC to the thrombus proximal end, and then, the microwire guided the microcatheter through the thrombus to the distal end of the occlusive artery. Then, the SR was advanced through the microcatheter and deployed across the thrombus (we recommended the microcatheter be withdrawn before thrombus extraction to increase the aspirational cross-sectional luminal area). Finally, about 5 min after deploying SR, we withdrew SR into the AC or withdrew the SR+AC as one unit under continuous aspiration using the AC. The CA was applied using a 50 mL syringe manually or an aspiration pump.

Devices

The following types of SR were used: Trevo (Stryker), Reco (Jiangsu Nico), Revive (Cordis) or Solitaire FR (Medtronic) device. The following ACs were used: Penumbra ACE60 reperfusion catheter (Penumbra), Catalyst 5/6 (Stryker), Sofia/Sofia plus (Microvention) or Navien 058/072 (Medtronic).[16]

Only trained and experienced neurointerventionists were allowed to perform MT for LVO in the ANGEL-ACT registry, and the first-line thrombectomy technique selection was as per the neurointerventionists' preference.

Outcome measure

Successful recanalisation of the target artery after the first technique alone was the primary outcome. The

secondary outcomes included complete recanalisation after first technique alone, first-pass successful/complete recanalisation, procedure duration, number of MT attempts, successful/complete recanalisation after all procedures, rescue treatment (switching to another thrombectomy technique after three attempts and balloon angiography/stenting), change in NIHSS score at 24 hours, 90-day mRS ordinal distribution, 90-day mRS of 0–1, 0–2, 0–3 as dichotomous variables. According to the standardised interview protocol, the trained investigator, who was blinded to clinical information, assessed the mRS score through the interview over the phone. Intraprocedure embolisation, parenchymal haemorrhage (PH) type 1 within 24 hours, PH2 within 24 hours, any intracranial haemorrhage (ICH) within 24 hours, symptomatic ICH (SICH) within 24 hours and 90-day mRS 6 were the safety outcomes. PH1, PH2, any ICH and SICH were assessed according to Heidelberg Bleeding Classification.[17] Successful recanalisation was defined as mTICI of more than 2b grade, and complete recanalisation was defined as mTICI of 3 grade.

Statistical analysis

All statistical analyses were performed using SAS V.9.4 software (SAS Institute). We described variables using the median (IQR) and number (percentages) for continuous variables and categorical variables, respectively. We conducted the Pearson $\chi 2$ or Fisher's exact test for categorical variables and the Mann-Whitney U test for continuous variables as the univariable analyses. In order to compare the outcomes, we performed the binary logistic regression analysis, generalised linear analysis or ordinal logistic regression analysis, to analyse the adjusted ORs, β-coefficients or common OR with their 95% CIs. The potential confounders included in the above multivariable analyses were the variables with a p value of <0.05 in the univariable analyses. Furthermore, we adjusted the propensity score (PS) that was calculated by the logistic regression analysis, including all the baseline characteristics. We also explored the interactive effect between the MT first-line options and the following subgroups on the primary outcomes: age (<65 years old vs >65 years old), gender (male sex vs female sex), admission NIHSS (<15 vs ≥15), atrial fibrillation (yes vs no), pretreatment with intravenous thrombolysis (IVT) (yes vs no), underlying ICAD (yes vs no), occlusion sites (internal carotid artery vs middle cerebral artery (MCA) M1 segment vs MCA M2 segment vs vertebrobasilar artery), tandem occlusion (yes vs no), TOAST stroke subtypes (Trial of ORG 10172 in Acute Stroke Treatment criteria) (large arterial atherosclerosis (LAA) vs cardioembolism vs other or unknown aetiology vs undetermined aetiology), general anaesthesia (GA) (yes vs no). The interaction effect was tested by a logistic regression analysis that enrolled the corresponding multiplicative interaction term with adjustment for PS. Statistical significance was determined by a two-sided p value of <0.05.

RESULTS

Five hundred and sixty patients were excluded for the reasons listed below: (1) no EVT records (n=25); (2) ACA or PCA occlusions (n=37); (3) missing value for 90-day mRS (n=64); and (4) CA first-line or IAT first-line or balloon angioplasty first-line or stenting first-line (n=434). Finally, 1233 patients were enrolled in our study, of whom 1069 (86.7%) received SR alone first-line, and 164 (13.3%) received SR+CA first-line (figure 1).

Baseline information

In univariate analyses, patients from SR alone first-line group had lower median age (65 (55–73) vs 69 (58–77), p=0.007), lower atrial fibrillation rate (34.1% vs 46.3%, p=0.002), lower pretreatment with IVT rate (26.2% vs 33.5%, p=0.049), higher tandem occlusion rate (14.7% vs 7.3%, p=0.011), higher GA rate (41.2% vs 26.8%, p=0.001) and higher heparin rate during the procedure (51.1% vs 40.2%, p=0.010) than SR+CA first-line group. Other baseline characteristics were similar (all p>0.05) between SR alone first-line and SR+CA first-line groups (table 1).

Outcome measure

In table 2, we observed the comparison of outcome measures after being adjusted by model 1 and model 2. There was no significant difference between SR first-line alone group and SR+CA first-line group regarding the successful recanalisation after the first technique alone as the primary outcome (66.8% vs 65.9%, p=0.812). In regard to the secondary outcomes, we found that SR+CA first-line group had a larger number of MT device passes (3 (2–4) vs 2 (1–2); model 1, β=1.77, 95% CI=1.55 to 1.99, p<0.001; model 2, β=1.76, 95% CI=1.54 to 1.98, p<0.001), longer procedure duration (86 (60–129) min vs 80 (50–122) min; β=10.76, 95% CI=1.08 to 20.43, p=0.029 (model 1); β=9.96, 95% CI=0.22 to 19.70, p=0.045 (model 2)) than SR alone first-line group. Other secondary and safety outcomes were observed to be comparable (all p>0.05) between SR alone first-line and SR+CA first-line groups.

Subgroup analysis

Figure 2 showed the results of the subgroup analysis and found significant interaction effects between treatment options and the subgroups stratified by atrial fibrillation (p for interaction=0.016) and GA (p for interaction=0.036) on the primary outcome.

DISCUSSION

In our study, we found that (1) the number of patients with SR alone first-line was approximately 6.5 times higher than those of patients with SR+CA first-line for acute LVO in the ANGEL-ACT registry; (2) SR+CA first-line led to more MT passes, longer procedure duration and similar successful recanalisation rate after first technique alone compared with first-line SR alone, which varied from the results of the ASTER 2 trial; (3) SR+CA first-line resulted

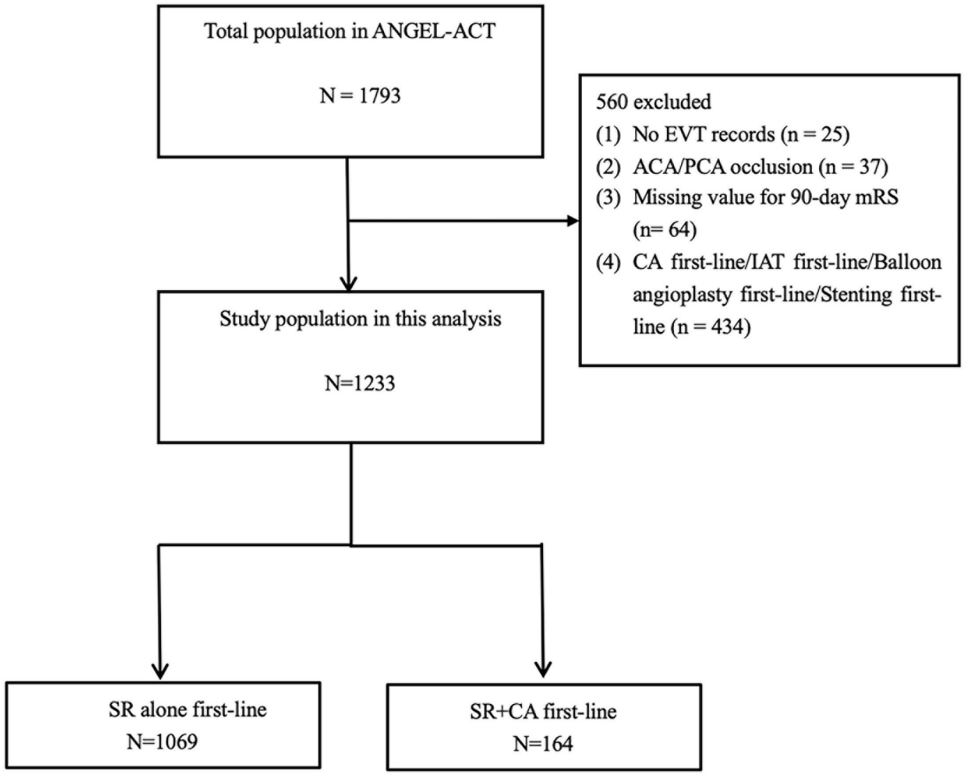

Figure 1 Flow chart of patient selection. ACA, anterior cerebral artery; CA, contact aspiration; EVT, endovascular thrombectomy; IAT, intra-arterial thrombolysis; mRS, modified Rankin Scale; PCA, posterior cerebral artery; SR, stent retriever.

in similar successful/complete recanalisation rate at the end of the procedure, complete recanalisation after first technique alone, first-pass successful/complete recanalisation rate, NIHSS changed at 24 hours, 90-day mRS 0–2 rate, mortality, PH1 rate, PH2 rate and SICH rate, which was in line with the results of ASTER 2 trial[12]; (4) subgroups stratified by atrial fibrillation and GA had interaction effects with different MT first-line techniques on the primary outcome.

Following the publication of five landmark RCTs in 2015, the American Heart Association/American Stroke Association stroke guideline has suggested SR as the only MT technique for LVO (class I; level of evidence A).[1 18] As a result, the SR first-line alone has developed and become popular in China since then. Currently, there are still no RCTs demonstrating the superiority of first-line SR+CA over first-line SR alone so far. In real-world practice, first-line SR+CA might increase additional costs compared with first-line SR alone. Meder *et al* reported that switching from SR alone to SR+CA could increase approximately 30% of the direct costs of MT in their institution.[8] In addition, the AC was not widely used throughout China during the study period, resulting in its non-availability in some hospitals.[16] For the above reasons, the neurointerventionists in China preferred to use the SR alone for the first-line thrombectomy procedure during the study period.

Notably, we found first-line SR+CA had more MT passes, longer procedure duration and a similar successful recanalisation rate after first technique alone compared with first-line SR alone with the adjustment for the confounders and PS, which was different from the previous studies reported.[7–12 19 20] Three reasons might explain the difference: first, the high incidence of LVO due to LAA was found high in China, which was reported in 52.7% of patients from the ANGEL-ACT registry,[21] and patients with LAA were more vascular tortuous. Arterial tortuosity might be associated with LAA,[22] which could make it difficult for the AC to reach the thrombus location and thus result in SR+CA first-line group having more MT passes and longer procedure duration than SR alone first-line group. Second, unlike previous studies, the balloon guiding catheter (BGC) was only used in 4‰ of patients from the ANGEL-ACT registry, which might also lead to different results between our and previous studies. However, Blasco *et al* also found that first-line SR+CA had a longer procedure duration than first-line SR alone, although all patients enrolled in their study used BGC.[23] Third, the experience and preference of the neurointerventionists for the first-line thrombectomy technique might also be another possible explanation. As the procedure of SR+CA combination was more complex than SR alone, less experience for SR+CA combination could result in longer procedure duration, and more MT passes to achieve successful recanalisation.[24] During the study period, most neurointerventionists preferred SR alone in order to achieve rapid, successful recanalisation, which might limit the experience of SR+CA combination accumulation and thus lead to the experience relative shortage. Apart from the successful recanalisation

Table 1 Baseline and procedure variables between SR alone first-line and SR+CA first-line groups

Baseline and procedure variables	SR alone first-line (n=1069)	SR+CA first-line (n=164)	P value
Age, years, median (IQR)	65 (55–73)	69 (58–77)	**0.007**
Male sex, n (%)	684 (64.0)	97 (59.2)	0.231
Transport mode, n (%)			0.846
Mothership	676 (63.2)	105 (64.0)	
Transfer	393 (36.8)	59 (36.0)	
Hypertension, n (%)	606 (56.7)	88 (53.7)	0.466
Diabetes mellitus, n (%)	184 (17.2)	30 (18.3)	0.734
Hyperlipidaemia, n (%)	94 (8.8)	15 (9.2)	0.882
Coronary heart disease, n (%)	166 (15.5)	26 (15.9)	0.915
Atrial fibrillation, n (%)	364 (34.1)	76 (46.3)	**0.002**
Prior stroke, n (%)	221 (20.7)	44 (26.8)	0.074
Smoking history, n (%)			0.242
Never smoking	666 (62.3)	93 (56.7)	
Previous smoking	72 (6.7)	16 (9.8)	
Current smoking	331 (31.0)	55 (33.5)	
SBP, mm Hg	145 (130–160)	145 (130–158)	0.187
Admission NIHSS*	17 (12–22)	16 (12–21)	0.123
Admission ASPECTS†	9 (7–10)	9 (7–10)	0.490
Blood glucose, mmol/L, median (IQR)	7.1 (6.0–8.8)	6.9 (5.8–7.7)	0.063
Antiplatelets before EVT, n (%)	161 (15.1)	23 (14.0)	0.729
Anticoagulants before EVT, n (%)	50 (4.7)	6 (3.7)	0.560
Pretreatment with IVT, n (%)	280 (26.2)	55 (33.5)	**0.049**
Occlusion site, n (%)			0.663
ICA	256 (24.0)	38 (23.2)	
M1	496 (46.4)	84 (51.2)	
M2	100 (9.4)	14 (8.5)	
Vertebrobasilar artery	217 (20.3)	28 (17.1)	
Tandem occlusion, n (%)	157 (14.7)	12 (7.3)	**0.011**
Underlying ICAD, n (%)			0.404
Yes	313 (29.3)	40 (24.4)	
No	644 (60.2)	104 (63.4)	
Undetermined	112 (10.5)	20 (12.2)	
Stroke subtype by TOAST criteria, n (%)			0.062
Large artery atherosclerosis	496 (46.4)	65 (39.6)	
Cardioembolism	394 (36.9)	76 (46.3)	
Other or unknown aetiology	128 (12.0)	13 (7.9)	
Undetermined	51 (4.8)	10 (6.1)	
General anaesthesia, n (%)	440 (41.2)	44 (26.8)	**0.001**
GP IIb/IIIa receptor inhibitor, n (%)	559 (52.3)	81 (49.4)	0.489
Heparin during the procedure, n (%)	546 (51.1)	66 (40.2)	**0.010**
OTP, min, median (IQR)‡	300 (215–440)	295 (225–415)	0.950

Bold values indicate statistical significance
*Six missing data.
†Eight missing data.
‡Ten missing data.
ASPECTS, Alberta Stroke Program Early CT Score; CA, contact aspiration; EVT, endovascular thrombectomy; GP, glycoprotein; ICA, intracranial cerebral artery; ICAD, intracranial atherosclerotic disease; IVT, intravenous thrombolysis; M1, middle cerebral artery M1 segment; M2, middle cerebral artery M2 segment; NIHSS, National Institutes of Health Stroke Scale; OTP, onset-to-puncture time; SBP, systolic blood pressure; SR, stent retriever; TOAST, Trial of ORG 10172 in Acute Stroke Treatment criteria.

rate after first technique alone, number of MT passes and procedure duration, our other results aligned with the ASTER 2 trial.[12] Nevertheless, our study showed the high rates of successful recanalisation after all procedures (91.2% vs 85.6% and 91.5% vs 86.2%), complete recanalisation after all procedures (70.2% vs 27.7% and 67.7% vs 32.0%), first-pass complete recanalisation (34.8% vs 17.8% and 34.2% vs 24.1%) and 90-day mRS 0–2 (43.8% vs 41.9% and 43.3% vs 38.0%) compared with the ASTER 2 trial in SR alone first-line and SR+CA first-line, respectively.[12] Therefore, the two first-line thrombectomy techniques seemed to have a similar clinical impact in patients with acute LVO. A recent meta-analysis reported that SR+CA first-line could lead to higher odds of a first-pass effect than SR first-line alone, but similar final recanalisation and functional independence were found between the two groups.[25] However, the cost-effectiveness of the entire thrombectomy technique was still known. Future studies are needed to investigate it.

The reasons for recanalisation failure for LVO by MT remains unclear, although previous studies have reported several factors, such as occlusion sites, tandem lesions, underlying ICAD, TOAST subtypes, the added value of IVT, thrombus properties, vascular access problems, embolic complications and failed procedures.[26 27] We performed the subgroup analysis to explore the potential reasons for recanalisation failure between SR alone first-line and SR+CA first-line. Our study found that SR+CA first-line was less effective than SR alone first-line regarding successful recanalisation after first technique alone for patients with LVO with atrial fibrillation as compared with patients with LVO without atrial fibrillation, possibly due to different thrombus properties (fibrin-rich clots or red blood cell-rich) between patients with atrial fibrillation and those without atrial fibrillation.[28] Moreover, our study noted that the SR+CA first-line showed more effective than SR alone first-line when patients with LVO received GA during the procedure. A plausible explanation might be that GA could provide

Table 2 Outcome comparison between SR alone first-line and SR+CA first-line groups

			Unadjusted model		Adjusted model 1*		Adjusted model 2†	
Outcomes	**SR alone first-line**	**SR+CA first-line**	**Effect size (95% CI)**	**P value**	**Effect size (95% CI)**	**P value**	**Effect size (95% CI)**	**P value**
Primary outcome								
Successful recanalisation after first technique alone, n(%)‡	714 (66.8)	108 (65.9)	0.96 (0.68 to 1.36)	0.812	0.83 (0.58 to 1.20)	0.323	0.85 (0.60 to 1.22)	0.376
Secondary outcomes								
Complete recanalisation after first technique alone, n(%)§	560 (52.4)	84 (51.2)	0.95 (0.69 to 1.33)	0.781	0.85(0.61-1.20)	0.357	0.86 (0.62 to 1.21)	0.392
First-pass successful recanalisation, n (%)‡††	536 (50.1)	81 (49.4)	0.97 (0.70 to 1.35)	0.858	0.93 (0.67 to 1.30)	0.665	0.95 (0.68 to 1.33)	0.771
First-pass complete recanalisation, n (%)§††	371 (34.8)	56 (34.2)	0.97 (0.69 to 1.38)	0.876	0.93 (0.65 to 1.32)	0.666	0.94 (0.66 to 1.34)	0.731
Number of MT attempts, median (IQR)	2 (1–2)	3 (2–4)	1.81 (1.59 to 2.03)	**<0.001**	1.77 (1.55 to 1.99)	**<0.001**	1.76 (1.54 to 1.98)	**<0.001**
Procedure duration, min, median (IQR)	80 (50–122)	86 (60–129)	5.77 (–3.90 to 15.45)	0.242	10.76 (1.08 to 20.43)	**0.029**	9.96 (0.22 to 19.70)	**0.045**
Successful recanalisation after all procedures, n (%)	975 (91.2)	150 (91.5)	1.03 (0.57 to 1.86)	0.915	1.10 (0.61 to 2.00)	0.757	1.12 (0.61 to 2.03)	0.719
Complete recanalisation after all procedures, n (%)	750 (70.2)	111 (67.7)	0.89 (0.63 to 1.27)	0.520	0.86 (0.60 to 1.23)	0.411	0.87 (0.61 to 1.25)	0.461
Rescue treatment								
Switching to other thrombectomy technique after 3 attempts, n (%)	49 (4.6)	11 (6.7)	1.50 (0.76 to 2.94)	0.242	1.27 (0.64 to 2.54)	0.492	1.24 (0.62 to 2.48)	0.538
Balloon angioplasty/stenting, n (%)	160 (15.0)	18 (11.0)	0.70 (0.42 to 1.18)	0.178	0.91 (0.53 to 1.56)	0.731	0.85 (0.50 to 1.45)	0.554
NIHSS score changed at 24 hours, median (IQR)	–5 (–10 to 0)	–4 (–9 to –1)	0.73 (–0.77 to 2.23)	0.338	1.15 (–0.36 to 2.66)	0.135	1.09 (–0.42 to 2.61)	0.157
90-day mRS, median (IQR)	3 (0–5)	3 (0–5)	0.99 (0.91 to 1.08)	0.493	1.12 (0.84 to 1.51)	0.445	1.10 (0.82 to 1.48)	0.527
90-day mRS 0–1, n (%)	423 (39.6)	66 (40.2)	1.03 (0.74 to 1.44)	0.870	1.01 (0.71 to 1.43)	0.957	1.03 (0.73 to 1.44)	0.883
90-day mRS 0–2, n (%)	468 (43.8)	71 (43.3)	0.98 (0.70 to 1.37)	0.907	0.96 (0.68 to 1.36)	0.812	0.97 (0.70 to 1.36)	0.877
90-day mRS 0–3, n (%)	582 (54.4)	92 (56.1)	1.07 (0.77 to 1.49)	0.693	1.06 (0.75 to 1.50)	0.729	1.07 (0.76 to 1.49)	0.714
Safety outcomes								
Intraprocedure embolisation, n (%)	57 (5.3)	13 (7.9)	1.53 (0.82 to 2.86)	0.181	1.24 (0.65 to 2.35)	0.519	1.19 (0.63 to 2.28)	0.591
Parenchymal haemorrhage type 1, n (%)¶	52 (5.0)	9 (5.7)	1.13 (0.55 to 2.35)	0.735	1.09 (0.52 to 2.28)	0.828	1.07 (0.51 to 2.25)	0.857
Parenchymal haemorrhage type 2, n (%)¶	43 (4.2)	7 (4.4)	1.06 (0.47 to 2.41)	0.885	1.04 (0.45 to 2.41)	0.925	0.99 (0.43 to 2.28)	0.987
Symptomatic intracranial haemorrhage, n (%)**	70 (6.8)	14 (8.9)	1.33 (0.73 to 2.42)	0.352	1.32 (0.71 to 2.46)	0.374	1.28 (0.70 to 2.36)	0.427
Any intracranial haemorrhage, n (%)¶	225 (21.7)	42 (26.4)	1.29 (0.88 to 1.89)	0.189	1.25 (0.84 to 1.85)	0.274	1.22 (0.82 to 1.79)	0.326
90-day mRS 6, n (%)	186 (17.4)	20 (12.2)	0.66 (0.40 to 1.08)	0.098	0.68 (0.41 to 1.13)	0.137	0.68 (0.41 to 1.12)	0.127

Bold values indicate statistical significance
*All the baseline variables with p<0.05 in univariable analysis between both groups including age, atrial fibrillation, tandem occlusion, pretreatment with IVT, general anaesthesia and heparin during the procedure were adjusted.
†Adjusted for the propensity score.
‡Defined as mTICI 2b–3.
§Defined as mTICI 3.
¶Thirty-nine missing data.
**Forty-eight missing data.
†† Two missing data.
CA, contact aspiration; IVT, intravenous thrombolysis; mRS, modified Rankin Scale; MT, mechanical thrombectomy; mTICI, modified Thrombolysis in Cerebral Infarction; NIHSS, National Institutes of Health Stroke Scale; SR, stent retriever.

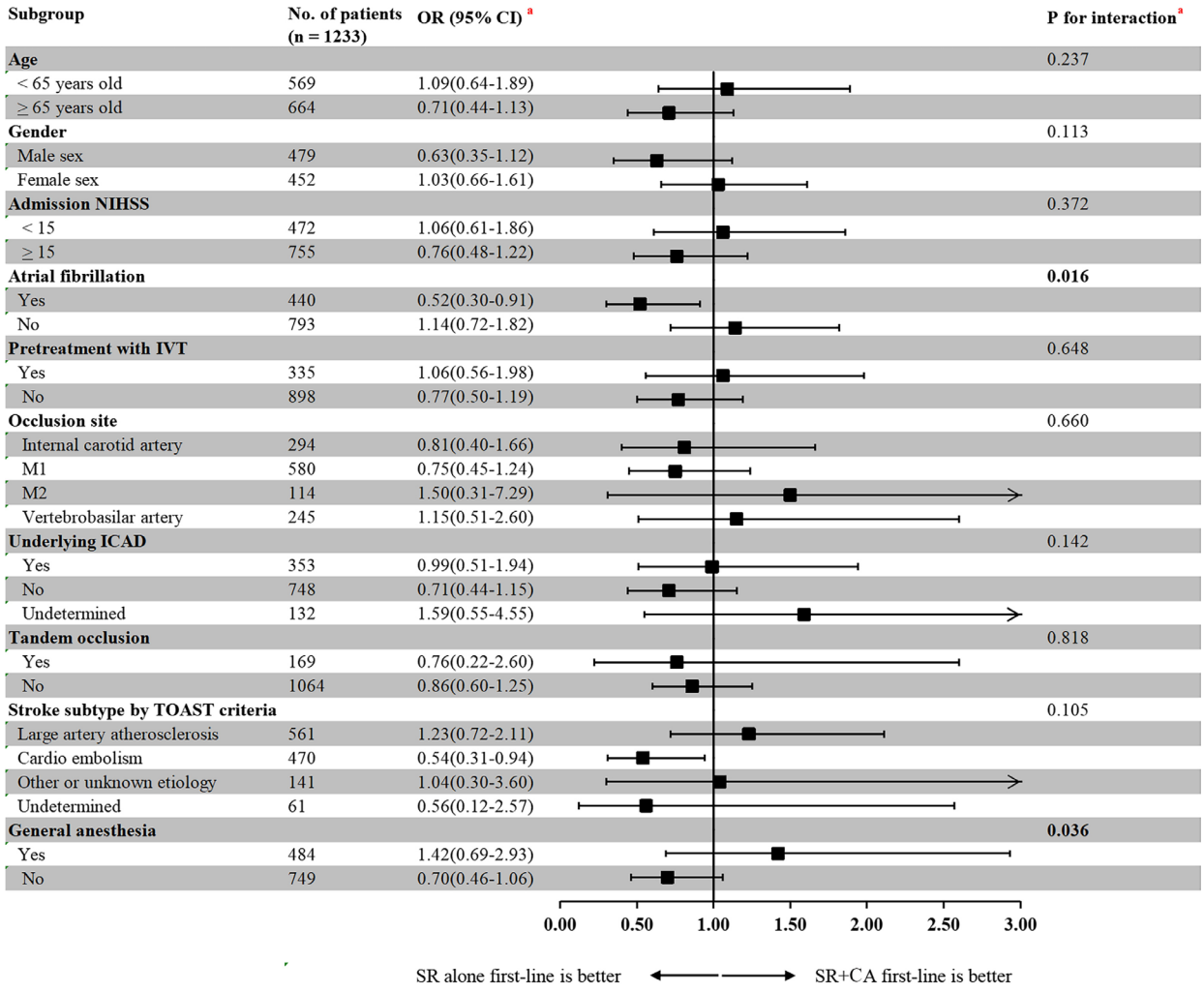

Figure 2 Treatment effects on the primary outcome according to exploratory subgroups. [a]Adjusted for the propensity score. CA, contact aspiration; ICAD, intracranial atherosclerotic disease; IVT, intravenous thrombolysis; NIHSS, National Institutes of Health Stroke Scale; SR, stent retriever; TOAST, Trial of ORG 10172 in Acute Stroke Treatment criteria.

greater patient immobilisation and controlled apnoea at critical times during the procedure than no anaesthesia, which allowed the neurointerventionalists to deliver SR and AC to the thrombus location as soon as possible, thereby maximising the effectiveness of SR+CA.[29] Accordingly, SR+CA first-line may be more effective than SR alone first-line in certain patients with LVO.

The current comparative analysis had some limitations. First, this study was not a randomised controlled study, which could result in selection bias. Furthermore, some measured or unmeasured variables (eg, neurointerventionists' experience and preference for first-line thrombectomy technique) could confound our results despite using multiple adjustment models. Second, we did not use the expanded Thrombolysis In Cerebral Infarction score (eTICI)[30] instead of mTICI to assess the target vessel recanalisation level since the ANGEL-ACT registry study started much earlier than the study about eTICI was published. Third, SR+CA first-line group had relatively few patients, which may introduce the type II error during the statistical analysis. Fourth, there are several SR+CA thrombectomy techniques such as 'Solumbra', 'SAVE' (stent retriever-assisted vacuum-locked extraction) and 'ARTS' (aspiration–retriever technique for stroke) which may lead to different recanalisation results.[31 32] However, we did not collect that variable, which might bias our findings. Finally, as high rate of LAA stroke subtype, long-time duration of workflow before EVT and very low rate of BGC used in the ANGEL-ACT registry[13 21] might bias the results and could not be generalised to other ethnic populations adequately.

CONCLUSIONS

Our results demonstrated that SR+CA first-line was not superior to SR alone for final recanalisation rate, first-pass recanalisation rate and 90-day clinical outcomes in the Chinese population. The combination of SR and CA first-line was associated with more MT passes and longer procedure duration than SR alone first-line. However, SR+CA first-line may be more effective than SR alone

first-line in certain patients with LVO such as patients undergoing GA or without atrial fibrillation.

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